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LUMINARY MEMO #247

To: Distribution
From: D. Millard
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Subject: Level 6 Test Description for Mission 17 (PRELIMINARY)

This memo provides a description of the LUMINARY Level 6 Digital Performance Testing currently planned for Mission 16.7. Included are comments on test initialization and a detailed description of the digital simulation tests which fall into the following general categories.

- 6.1.0 ASCENT AND RENDEZVOUS
- 6.2.0 ABORT FROM DESCENT
- 6.3.0 LUNAR SURFACE OPERATION AND ALIGNMENTS
- 6.4.0 LUNAR LANDING
- 6.5.0 ERASABLE MEMORY PROGRAMS
- 6.6.0 SPECIAL TESTS

The test initialization listed below applies to all the tests and any special initial conditions will be specified in the detailed test description.

- 1) 1σ IMU, Radar, State Vector Errors
- 2) Normal Astronaut Interface from Apollo 17 Data File
- 3) Apollo 17 Operational Trajectory
- 4) Apollo 17 Erasable Load
- 5) 71/72 Ephemeris
- 6) 10% TLOSS
- 7) LM12 Vehicle

Flight

Typical 1σ initialization errors are given on page 2.

TYPICAL 1 SIGMA INITIALIZATION ERRORS

IMU ERRORS

	X	Y	Z
Misalignment (milliradians)	1.0	1.0	1.0
Bias Drift (MERU)	2.00	2.00	2.00
Input Axis Drift (MERU/G)	8.00	-8.00	8.00
Spin Axis Drift (MERU/G)	-5.00	5.00	-5.00
PIPA Bias (CM/SEC ²)	.20	.20	.20
PIPA Scale Factor (PPM)	-116	-116	-116

STATE VECTOR ERRORS AT PDI IGNITION

	ALTITUDE	CROSS-RANGE	DOWN-TRACK
POSITION (ft.)	-1410	1080	-4220
VELOCITY (fps.)	4.3	1.28	-1.38

RENDEZVOUS RADAR ERRORS

	BIAS	RANDOM
RANGE (ft.)	800 if $R > 50.8$ N.M. 80 if $R \leq 50.8$ N.M.	.3% R
RANGE-RATE (fps)	.3	.4% \dot{R} (MINIMUM .0044 fps)
SHAFT/TRUNNION (Mr.)	15.0	1.0

LANDING RADAR ERRORS

	RANDOM	MINIMUM
ALTITUDE (ft.)	.5%	5
VX (fps)	.5%	.8
VY (fps)	.7%	.8
VZ (fps)	1.0%	.8

3.1.0 ASCENT AND RENDEZVOUS

The following applies to all tests in this section unless stated otherwise in the test description.

- a) The SLOSH environment is not simulated.
- b) The FAST IMU environment is used.

6.1.1 ASCENT AND RENDEZVOUS

I. Test Objective

Demonstrate LM Ascent from the lunar surface and LM active short Rendezvous.

II. Test Description

The LM is tilted approximately 10° on the Lunar Surface.

Program Sequence

P57	AT-3 to Landing Site
P00	
V48	DAP Data Load
V41N72	Position RR
P12	Ascent
V64	S-Band Antenna
V82	Orbital Parameter Display (R30)
P00	
V48	DAP Data Load
P20	Rendezvous Navigation
V80	Enable LM State Vector Update
P34	Transfer Phase Initiation (TPI)
V83	Rendezvous Parameter Display (R31)
N52	Display LM Central Angle
N59	Display Delta LOS Vel.
V48	DAP Data Load
P42	APS
V82	Orbital Parameter Display (R30)
P35	Transfer Phase Midcourse (TPM)
V67	W-Matrix Display
V48	DAP Data Load
V83	Rendezvous Parameter Display (R31)

P41	RCS
V82	Orbital Parameter Display
P35	Transfer Phase Midcourse (TPM)
V93	Enable W-Matrix Initialization
P41	RCS
V82	Orbital Parameter Display
P00	
V48	DAP Data Load
P47	Thrust Monitor
P00	

6.2.0 ABORTS FROM DESCENT

The following applies to all tests in this section unless indicated differently in test description.

- a) The LM is yawed left 70 degrees at PDI-3 mins.
The 70 degrees yaw is removed at PDI +3 mins. This maneuver is done in the AUTO mode.
manually
- b) The AUTO throttle and ABORT back up discretes are set.
- c) The abort switch is failed ON.
- d) The SLOSH environment model is not simulated.
- e) The environmental FAST IMU is used.
- f) Abort sequence:
Switch to ATTHOLD
Full Throttle
ABORT or ABORT STAGE
V22N46 ENTER ENTER
Switch to AUTO
- g) Terrain slope error of -1 degree.

TEST 6.2.1 ABORT AT 33 K. FT.

I. Test Objective

Demonstrate DPS Abort from descent.

II. Test Description

Program Sequence

P00

V48 DAP Data Load

V64 S-Band Antenna Routine (R05)

P63 Braking Phase Program

V57 LR Update (R12)

ABORT sequence at 33 K ft. altitude.

P70 DPS Abort Program

N76 Monitor Desired HVEL, RVEL, Crossrange

N77 Monitor TTOGO, VGY, ABVEL

N85 Monitor VG

P00 LGC Idle Program

V64 S-Band Antenna Routine (R05)

V82 Orbital Parameter Display Routine (R30)

V83 Rendezvous Parameter Display Routine (R31)

P20 Rendezvous Navigation Program

P32 Coelliptic Sequence Initiation Program

TEST 6.2.2 ABORT AT 7 K. FT.

I. Test Objectives

Demonstrate DPS and APS Abort from descent.

II. Test Description

The abort switch is failed OPEN requiring the astronaut to select P70 via DSKY.

press 6 says the ABORT backup decelerate is set

Program Sequence

P00

V48 DAP data load

V64 S-Band Antenna Routine (R05)

P63 Braking Phase

V57 LR Update (R12)

P64 Approach Phase

 ATTHOLD at 7 K ft.

 Full throttle

 V22N46 EE

P70 DPS Abort select by Astronaut

 AUTO mode

ABORT STAGE at DPS depletion

P71 APS Abort

N76 Monitor Desired Horizontal, Radial Vel, Crossrange

N77 Monitor TTOGO, VGY, ABVEL

N85 Monitor VG

P00

V64 S-Band Antenna Routine (R05)

V82 Orbital Parameter Display (R30)

V83 Rendezvous Parameter Display (R31)

P20 Rendezvous Navigation

P32 Coelliptic Sequence Initiation

TEST 6. 2. 3 ABORT AFTER TOUCHDOWN

I. Test Objective

Demonstrate APS (T1) Abort

II. Test Description

The Auto Throttle is failed off.

Program Sequence

P00

V48 DAP Data Load

V64 S-Band Antenna Routine (R05)

P63 Braking Phase

V57 LR Update Enable

P64 Approach Phase

P66 Vertical Phase

ABORT Sequence at Lunar Surface Touchdown

P71 APS Abort

P00

V64 S-Band Antenna Routine (R05)

V82 Orbital Parameter Display (R30)

V83 Rendezvous Parameter Display (R31)

P20 Rendezvous Navigation

P32 Coelliptic Sequence Initiation

6.3.0 LUNAR SURFACE OPERATION AND ALIGNMENTS

TEST 6.3.1 LUNAR SURFACE OPERATIONS

I. Test Objective

Demonstrate LM IMU Lunar Surface alignments and operations.

II. Test Description

The LM is tilted approximately 10° on the Lunar Surface.

Program Sequence

P68	Lunar Surface Confirmation Program
P00	
P12	Ascent Program
P57	AT-3 Lunar Surface Alignment to REFSMMAT Recycle Gravity Determination
V47	AGS Initialization
V41N20	Park IMU Coarse align IMU to parking gimbal angles
P06	LGC Power Down Program LGC Power Up
P57	AT-3 Lunar Surface Alignment to Landing Site 4 Star sightings
V63	RR Self test
P22	Lunar Surface Navigation (No Update Mode)
P57	AT-3 Lunar Surface Alignment to Landing Site
V47	AGS Initialization
V48	DAP Data Load
V82	Orbital Parameter Display
P12	Ascent Program to TIG
P00	

6.4.0 LUNAR LANDING

The following applies to all tests in this section unless indicated differently in test description.

- a) The LM is yawed left 70 degrees at PDI -3 mins.
The 70 degree yaw is removed at PDI +3 mins. This maneuver is done in the AUTO mode.
- b) The AUTO throttle and ABORT back up discretes are set.
- c) The abort switch is failed ON and the auto throttle failed OFF.
- d) The SLOSH mode is not simulated.
- e) The environmental FAST IMU is simulated.
- f) Terrain slope error -1 degree

TEST 6.4.1 LUNAR LANDING - AUTO (ERROR FREE)

I. Test Objective

Demonstrate LM automatic landing.

II. Test Description

This test contains no initialization errors.

Program Sequence

P00	
V48	DAP data Load
V64	S-Band Antenna Routine (R05)
P63	Braking Phase
V57	LR Update Enable
N68	Monitor Range, TGO, Velocity
N92	Monitor THROTTLE CMD, HDOT, H
P64	Approach Phase
P66	Vertical Phase
P68	Lunar Surface Confirmation
P00	

TEST 6.4.2 LUNAR LANDING - AUTO

I. Test Objective

Demonstrate LM automatic landing.

II Test Description

This is the same as TEST 6.4.1 (ERROR FREE) except that it contains a -1 degree terrain slope error.

TEST 6.4.3 LUNAR LANDING - NOMINAL

I. Test Objection

Demonstrate LM automatic landing.

II. Test Description

This test exercises landing site redesignation option at PDI -10 mins. to correct propagated state vectors errors; at PDI +5 mins. to correct IMU errors and at PDI +8 mins. to correct altitude errors.

Test Sequence

P00

N69 Landing Site Redesignation at PDI -10 mins.

Downtrack

Crosstrack

V48 DAP Data Load

V64 S-Band Antenna Routine (R05)

P63 Braking Phase

V57 LR Update Enable

N69 Landing Site Redesignation at PDI +5 mins.

Downtrack

Crosstrack

N69 Landing Site Redesignation at PDI +8 mins.

Altitude

P64 Approach Phase

LPD ACA: AZ, EL

P66 Vertical Phase

P68 Lunar Surface Confirmation

P00

TEST 6.4.4 LUNAR LANDING - MAX DOWNRANGE N69

I. Test Objective

Demonstrate LM nominal landing to offset landing site.

II. Test Description

This test exercises the landing site redesignation option N69 at PDI +2 and LPD during P64. The N69 redesignation offsets the actual landing site.

Program Sequence

P00	
V48	DAP Data Load
P63	Braking Phase
N69	Landing Site Redesignation at PDI +2 mins. Downtrack
P64	Approach Phase LPD ACA: AZ, EL
P66	Vertical Phase Entered manually at 700 ft.
P68	Lunar Surface Confirmation
P00	

6.5.0 ERASABLE MEMORY PROGRAMS

Only those EMPs specified in the flight plan for a nominal mission will be reported on.

EMP 99 LM DEORBIT

TEST 6.5.1

TEST 6.5.1 LM DEORBIT

I Test Objective

Demonstrate LM deorbit using Erasable Memory Program 99.

II Test Description

Test Sequence

P00

Load EMP 99

V48 DAP Data Load

V47 AGS Initialization

P30 External Delta-V

Verify Noun 26

V62 Display Total Attitude Errors

V30 Activate EMP 99

6.6.0 SPECIAL TESTS

The following applies to all tests in this section unless otherwise indicated in the test description.

- a) The SLOSH environment is not simulated.
- b) The FAST IMU environment is used.

6.6.1A DOI2 - ERROR FREE

I. Test Objectives

Demonstrate the DOI2 burn with no initialization errors.

II. Test Description

The LM is yawed left 70 degrees after DOI2.

The simulation is terminated at throttle up in P63.

Program Sequence

P00	
V48	DAP data load
V82	Orbited Parameter Display (R30)
P30	External Delta V targetting
P41	RCS Burn
V82	R30
V64	S-Band Antenna Routine (R05)
V48	DAP data load
P27	SV Update
P63	Braking Phase

6.6.1B DOI2

I. Test Objective

Demonstrate the DOI2 burn with 1σ errors.

II. Test Description

This is the same as TEST 6.6.1A, except that it is initialized with 1σ errors.

6.6.1C DOI2

I. Test Objective

Demonstrate the DOI2 burn with 1σ errors.

II. Test Description

This is the same as TEST 6.6.1B except that the 1σ state vector errors are reversed.

6. 6. 3 TEI Using DPS

I. Test Objective

Demonstrate the TEI burn using the LM DPS.

II. Test Description

Program Sequence

P00

V48 DAP Data Load

V82 Orbital Parameter Display (R30)

P30 External Delta V Targeting

P40 DPS Burn

V82 R30

6.6.4 LOI Using DPS

I. Test Objective

Demonstrate the LOI burn using the LM DPS.

II. Test Description

Program Sequence

P00

V48 DAP Data Load

V82 Orbital Parameter Display (R30)

P30 External Delta V targetting

P40 DPS Burn

V82 R30